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(71) Applicant: NGK INSULATORS, LTD.
Nagoya City Aichi Pref. (JP)

(72) Inventors:
- Matsubara, Reiji
Aichi-Gun, Aichi Pref. (JP)
- Ikeshima, Koichi
Okazaki-City, Aichi Pref. (JP)

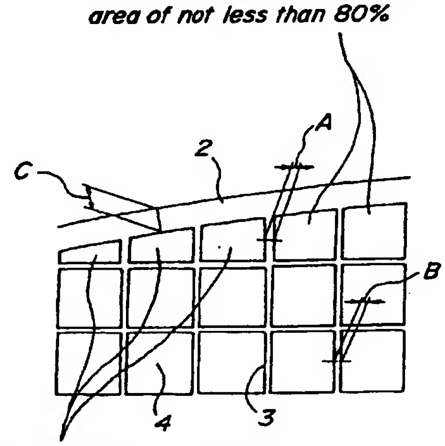
(74) Representative: Paget, Hugh Charles Edward et al
MEWBURN ELLIS
York House
23 Kingsway
London WC2B 6HP (GB)

(54) Ceramic honeycomb structural body with different wall thicknesses

(57) A ceramic honeycomb structural body comprises a plurality of open-ended cells defined by an outer peripheral wall and many cell walls, wherein cell walls constituting the irregular open-ended cells located near to the outer peripheral wall have a thickness thicker than those of the other remaining cell walls.

FIG_6

Open-ended cell having sectional area of not less than 80%



Open-ended cell having a sectional area of less than 80%

A : position for measuring cell wall thickness of irregular open-ended cell

B : position for measuring cell wall thickness of open-ended cell other than irregular open-ended cell

C : position for measuring thickness of outer peripheral wall

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pressure loss is hardly influenced.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein:

Fig. 1a is a perspective view of an embodiment of the ceramic honeycomb structural body to be noticed in the invention;
Fig. 1b is a partial sectional view of the structural body shown in Fig. 1a;
Fig. 2 is a schematic enlarged view illustrating compression load and bending load applied to a cell wall;
Fig. 3 is a partial schematic enlarged view illustrating the deformation of the cell wall;
Figs. 4a and 4b are partly broken elevation views of embodiments illustrating a construction of a catalyst converter using the honeycomb structural body, respectively;
Fig. 5 is a partial schematic view of an embodiment of an extrusion die usable for the extrusion of the ceramic honeycomb structural body according to the invention;
Fig. 6 is a partial schematic view illustrating positions of portions measured in the example;
Fig. 7 is a schematic view illustrating a method of measuring pressure loss in an outer peripheral portion of the ceramic honeycomb structural body in the example; and
Fig. 8 is a schematic view illustrating a method of measuring the strength of the outer peripheral wall in the example.

DESCRIPTION OF PREFERRED EMBODIMENTS

The details of attaining the invention will be described below.

Recently, social demands for automobile become higher and higher, and there are mentioned the following two demands with respect to the catalyst among them.

(1) The harmful components in the exhaust gas are rendered into zero as far as possible.
(2) The fuel consumption is reduced as far as possible.

As to these demands, a practicable remedy for the ceramic honeycomb structural body is to make the thickness of the cell wall thin as mentioned below.

At present, catalysts are widely used as means for decreasing harmful components in the exhaust gas. One of conditions of the ceramic honeycomb structural body contributing to improve the purification performance of the catalyst is a point that a heat capacity is decreased for rapidly raising the temperature of the catalyst to a working start temperature. Various methods of decreasing the heat capacity of the ceramic honeycomb structural body can be thought, but they are actually restricted as mentioned below. Firstly, it is thought to use a material having a small heat capacity, but the material is rather limited by the other important properties such as mechanical strength, heat resistance, thermal shock resistance and the like, so that the heat capacity of the structural body cannot be decreased by such a material. Secondly, it is thought to increase a porosity, but the increase of the porosity lowers the mechanical strength, so that it is impossible to increase the porosity. Thirdly, it is thought to decrease the number of cell walls, but since the purification performance of the catalyst is proportional to the geometric surface area of the structural body, it is impossible to decrease the number of open-ended cells defined by the cell walls. For these reasons, means for decreasing the heat capacity of the ceramic honeycomb structural body is only the thinning of the thickness of the cell wall.

On the other hand, it is considered that a pressure drop of the ceramic honeycomb structural body is minimized in order to reduce the fuel consumption. In order to minimize the pressure drop under a condition of ensuring the geometric surface area required for the purification performance, it is a best means to thin the cell walls of the ceramic honeycomb structural body.

As mentioned above, the thinning of the thickness in the cell walls of the ceramic honeycomb structural body is a beat means for fulfilling the above-mentioned requirements. However, when the thickness of the cell wall is thinned, the mechanical strength may naturally be lowered as a demerit.

The mechanical strength of the ceramic honeycomb structural body is a strength strongly and mechanically holding the structural body from external pressure even if the structural body is used as a support for the catalyst in an automobile and subjected to violent high heat and vibrations. That is, the ceramic honeycomb structural body is cool in a catalyst converter at the time of starting the automobile, so that a thermal expansible ceramic mat is interposed between a container for the catalyst converter and the structural body at a compressed state so as not to freely move the structural body inside the container even when vibrations are applied to the catalyst converter at the starting time. Then, when the catalyst converter is heated by heat from the exhaust gas during the running of the automobile, the thermal expansible ceramic mat is expanded to further increase pressure applied to the structural body. Therefore, the

eycomb structural body having a uniform cell wall thickness. In the above-mentioned technique disclosed in JP-B-62-18797 and JP-B-61-60320, the thickness of all cell walls existing in the outer peripheral portion is made thick, so that the flowing of the exhaust gas becomes more difficult as compared with that of the conventional ceramic honeycomb structural body having a uniform cell wall thickness. Therefore, there is no meaning in the use of the technique disclosed in these articles to the structure of the catalyst converter as shown in Fig. 4a.

It is confirmed that the pressure loss of the honeycomb structural body is most dependent upon a hydraulic radius given by dividing a sectional area of open-ended cell by its inner periphery as shown by the following experimental equation (1):

$$P=(0.2091\times L/F/D^2)+63.93\times(1-F)^2/F^2+10.95 \tag{1}$$

wherein

P: pressure loss at a flow rate of 16m/sec (mmH_2O)
L: full length of the honeycomb structural body (mm)
F: opening area ratio
D: hydraulic radius (mm).

Particularly, in the irregular open-ended cells having a triangle shape frequently seen when the angle defined by the outer peripheral wall and the cell wall is about 45°, the hydraulic radius is very small and the pressure loss is very large, so that the exhaust gas hardly flows even if the thickness of cell wall is not made thick. Therefore, even if the cell walls defining the irregular open-ended cell are thickened according to the invention, there is no influence on the flowing of the exhaust gas, so that the ceramic honeycomb structural body according to the invention is most preferable to be used in the structure of the catalyst converter as shown in Fig. 4a. Moreover, the sectional area of the irregular open-ended cell is less than about 80% of the sectional area of the regular open-ended cell having a square shape, considering that the flowing of the exhaust gas hardly occurs if the pressure loss becomes about two times.

As the ceramic material practically used at present, cordierite is selected from a viewpoint of the heat resistance and thermal shock resistance. Cordierite is usually used by combining natural material and industrial material, so that the outer dimension of the structural body made from cordierite changes in a range of several percentages in accordance with combination of starting material lots, scattering of manufacturing conditions and the like. In the catalyst converter for automobile, only the outer dimensional tolerance of 1-2% is generally acceptable in view of the holding in the container for the converter. In order to absorb such a tolerance, therefore, an extrusion die disclosed in JP-A-57-6722 as shown in Fig. 5 is used as an extrusion die for shaping the ceramic honeycomb structural body particularly having a cell wall thickness of less than 0.15 mm. In Fig. 5, the extrusion die 21 is composed of supply ports 22 for pottery body and slits 23 communicating therewith to extrude the honeycomb structural body 1 as shown in an upper portion of Fig. 5. The dimension of the outer shape of the structural body can be adjusted by setting masks 24 having different inner diameters at a back side of the extrusion die 21 in its extruding direction. This technique is applicable to the invention if the width of the slit corresponding to the cell wall defining the irregular open-ended cell is widened.

However, if it is intended to adjust the dimension of the outer shape of the honeycomb structural body disclosed in JP-B-5-41296 by using the extrusion die of the above structure, a size of a gradually increased portion of the cell walls also changes. In Fig. 5, when using the mask having an inner diameter A shown by a solid line, the gradually increased portion 25 is obtained, but when an inner diameter B shown by a phantom line is used so as to make the outer diameter of the honeycomb structural body small, the gradually increased portion is not formed. For this reason, if it is intended to adjust the dimension of the outer shape, there must be provided several kinds of the extrusion die, which becomes considerably uneconomical. Further, when the lateral section of the honeycomb structural body is circular or ellipsoidal, all of the cell walls contacting with the outer peripheral wall are different in the shape over a region corresponding to a quarter of the outer periphery, so that an electric discharge machining for the formation of the slits in the extrusion die, which has generally been conducted in the manufacture of the extrusion die as disclosed in JP-B-5-41296, cannot be conducted, and hence a mechanical machining is required instead of the electric discharge machining. As a result, the extrusion die can not be machined in a high precision.

The following examples are given in illustration of the invention and are not intended as limitations thereof.

At first, there are provided ceramic honeycomb structural bodies as invention examples and comparative examples, each having a configuration of 106 mm in diameter and 150 mm in full length shown in Fig. 1a obtained by sintering an extrusion shaped body of cordierite material, and the number of cells (open-ended cells), cell wall thickness and thickness of outer peripheral wall as shown in Tables 1 and 2. In this case, Comparative Example 1 is a most standardly and widely used ceramic honeycomb structural body in which all of cell walls defining the irregular open-ended cells

thermal shock resistance is represented by an average of the values measured with respect to five bodies. These test results are shown in Tables 1 and 2.

Table 2

Item	Number of cells (k cpsm)	Thickness of cell wall in central portion (mm)	Thickness of cell wall in outer peripheral portion (mm)	Thickness of cell wall defining irregular open-ended cell (mm)	Thickness of outer peripheral wall (mm)	Pressure loss in outer peripheral portion (mmH_2O)	External pressure at break (MPa)	Thermal shock resistance (°C)
Comparative Example 13	620	0.08	0.08	0.8	0.1	119	1.6	900
Comparative Example 14					0.3	120	1.8	900
Comparative Example 15					0.5	120	2.3	900
Comparative Example 16					0.7	120	1.7	890
Invention Example 7				0.10	0.3	120	2.0	900
Invention Example 8				0.12		118	2.3	880
Invention Example 9				0.14		120	2.5	900
Invention Example 10				0.16		119	2.4	890
Comparative Example 17	930	0.08	0.08	0.08	0.1	181	1.6	900
Comparative Example 18					0.3	180	1.8	900
Comparative Example 19					0.5	180	2.3	900
Comparative Example 20					0.7	181	1.7	890
Invention Example 11				0.10	0.3	180	2.0	900
Invention Example 12				0.12		180	2.3	880
Invention Example 13				0.14		179	2.5	900
Invention Example 14				0.16		179	2.4	890
Comparative Example 21	1395	0.08	0.08	0.08	0.1	272	2.6	900
Comparative Example 22					0.3	273	4.5	900
Comparative Example 23					0.5	274	4.7	910
Comparative Example 24					0.7	272	5.2	900
Invention Example 15				0.10	0.3	271	4.8	900
Invention Example 16				0.12		270	6.0	910
Invention Example 17				0.14		272	6.2	910
Invention Example 18				0.16		270	6.1	910

FIG_1a

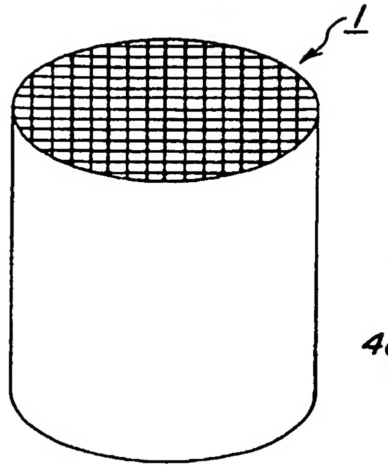

FIG_1b

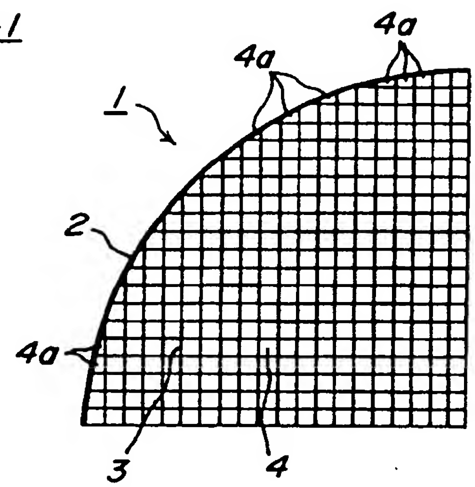

FIG_2

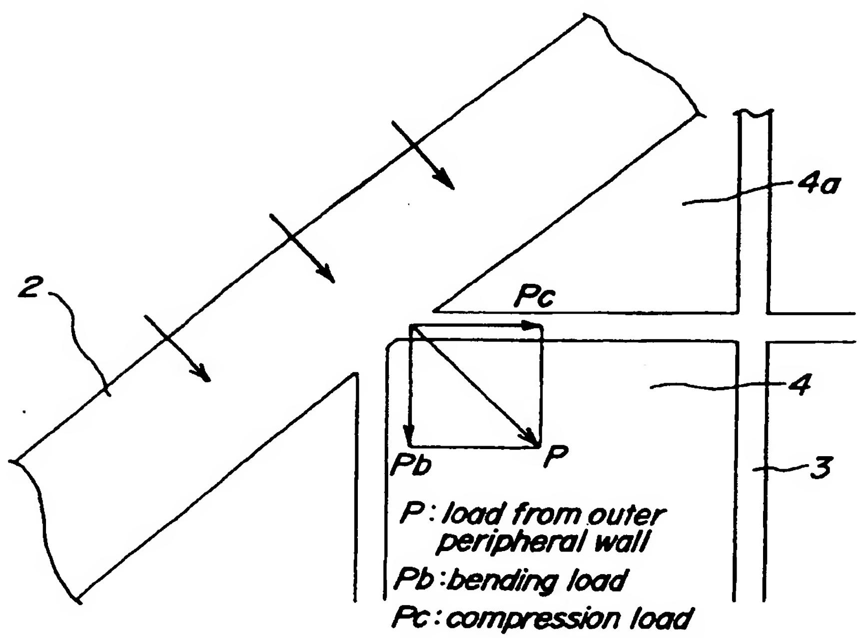

FIG_5

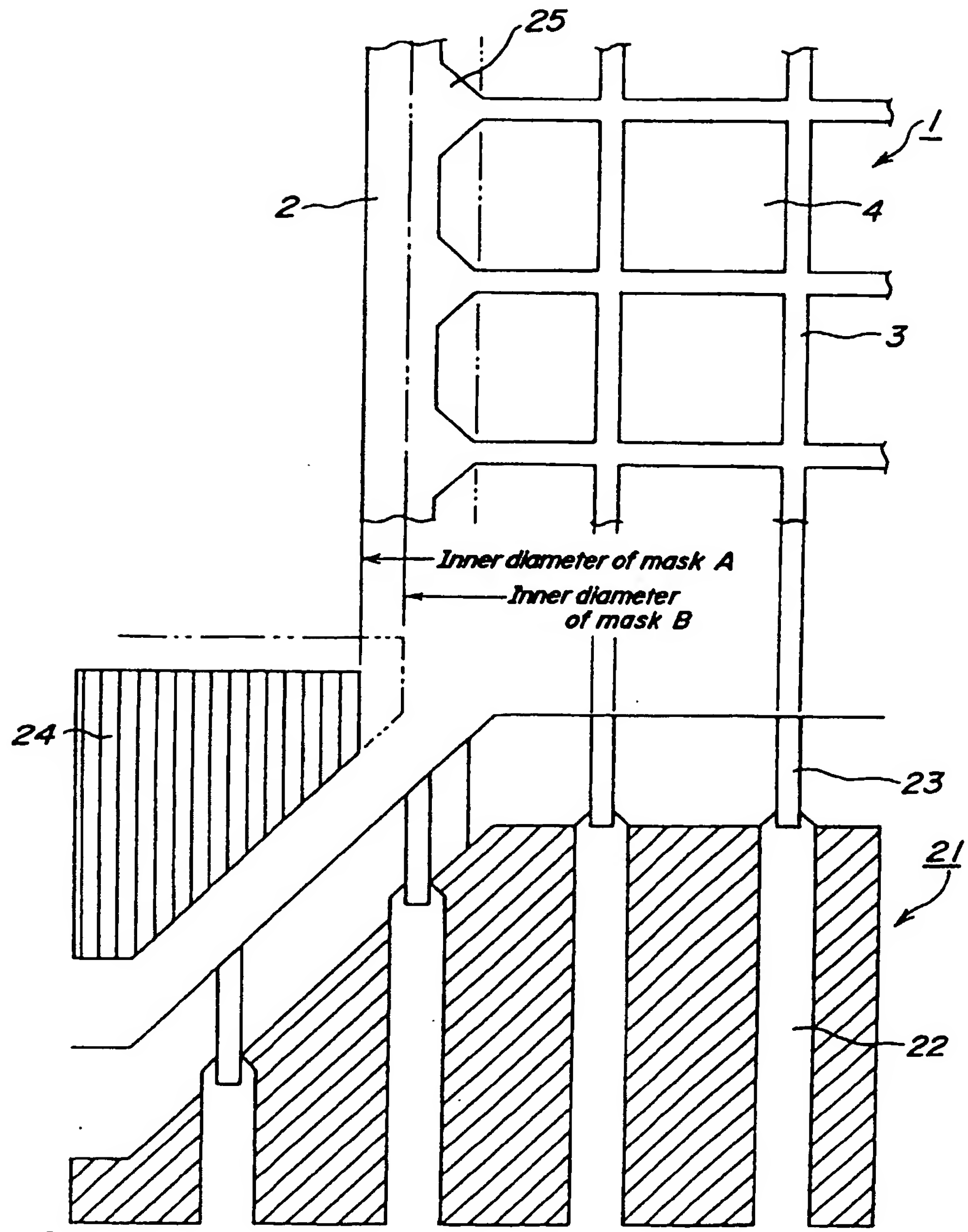

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FIG. 7